REAL TIME 3-D DISCRIMINATION OF BURIED OBJECT IN SUBSURFACE SOIL

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The Electrical Conductivity Object Locator (ECOL) has been developed with the goal of detecting buried objects. Its specific capability to detect and characterize small-size plastic and metal objects buried at shallow depths is demonstrated. The technique can also detect larger objects at greater depths. The ECOL technique maps the soil subsurface conductivity and identifies variations in the conductivity between buried objects and their surroundings. The subsurface conductivity is mapped in two major steps: 1) Low-frequency (1 to 100 Hz) and low-amplitude (<200 µA) currents injected into the soil induce potential and magnetic fields in and around the subsurface soil. The potential and magnetic fields are measured using appropriate sensors placed above the soil surface. 2) Using the measured values as boundary conditions, a fast optimization algorithm, and an accurate matrix inversion routine, the subsurface conductivity is estimated. The ECOL technology has been verified extensively through computer simulation and field tests. Computer simulations were conducted using small and large plastic and metal objects buried various depths between 10 and 50 meters; field-tests were conducted using small objects buried in shallow depths. They indicate that the ECOL technique is able to identify buried plastic discs (20 cm diameter; 5 cm thick) or metal discs (15 cm diameter, 7 cm thick) at shallow depths of about 15 cm. Note that during the field tests, the soil was cluttered with roots and pebbles, but the algorithm was able to filter out these objects. Also, the moisture content of the soil did not affect the ability to locate buried objects. During the field tests, conventional sensors, such as reference "half-cells", were used in measuring electrical potentials.

For real time processes, an array of sensors is used to measure the electrical potential along the direction of current flow; there are 15 sensors in the array with 10 cm separations. To take the potential measurements on the surface of the area of interest, two injection (I/O) terminals are placed 30 m apart on opposite sides of the area; and the sensor array is placed in a straight line and parallel to the line connecting the terminals and is moved from one end of the study area to the other in parallel placements, and with fixed spacing between each placement. A single "array measurement" consists of 14 potential value measurements taken between the 15 sensors. A sequential algorithm based on the simultaneous perturbation stochastic approximation (SPSA) method is developed to process one or more array measurements at one time. Array measurements may be repeated several times to cover a small section of the total area of interest until the subsurface there is fully analyzed. Then the process can progress to an adjacent section, as the situation permits. The number of array measurements can be varied in accordance with the size of the section. Previous array measurements may be reused, if the original subsurface has not been disturbed. In the current case study, the distance between array placements was set at 10 cm. To analyze adjacent subsurface, the injection terminals were moved laterally after every five array measurements, and then array measurements were taken for the new subsurface.